Drive circuit for a relay having at least one exciter coil for operation in a high temperature and/or high operating voltage range

In a drive circuit for a relay which has at least one exciter coil (RS) with relay armature and a changeover switch (S1), in which case, in the event of a specific minimum current through the exciter coil (RS), the changeover switch (S1) can be changed over from a first switching position into a second switching position by the relay armature, and in the case of which the current through the exciter coil is entirely reduced, after the changeover of the changeover switch (S1), to a value which is greater than or equal to the required holding current, it is provided that the exciter coil is connected in series with a constant-current source between the poles of the supply voltage,
and that the constant-current source can be set to different current values.

Description

The invention relates to a drive circuit for an electromechanical relay in the case of which at least one changeover switch can be changed over from a first switching position into a second switching position by a current through an exciter coil by means of a relay armature, in particular for use in motor vehicles. When used in motor vehicles, the drive circuit must be able to reliably switch the relay in a large temperature range (-40° to +85°C) even with greatly varying supply voltages of the motor vehicle electrical system (e.g. in the case of 12V nominal voltage from 6 to 24V). Finally, a specific holding current, in particular in operation at relatively high temperatures, also must not lead to an overload and destruction of the exciter coil. The prior art discloses using drive circuits which reduce the current through the exciter coil after the pull-in of the relay armature and changeover of the changeover switch. What is disadvantageous in this case is either that the circuits are of complicated and expensive construction or said circuits function only in a limited fashion.

Therefore, it is an object of the invention to specify a drive circuit for a relay having an exciter winding, a relay armature and a changeover switch which is brought to a second switching position from a first switching position by the relay armature and in the case of which the current is reduced after the pull-in of the relay armature, which drive circuit is of simple construction and nevertheless functions entirely satisfactorily under all the various operating conditions.

This object is achieved by means of a drive circuit in which the exciter coil of the relay is connected to a constant-current source between the poles of the supply

voltage, and in which the constant-current source is changed over after the pull-in of the relay armature in such a way that it supplies a current which is greater than or equal to the required holding current of the relay. What is advantageous in this case is that this circuit additionally compensates for component tolerances of the individual relay coil which, at a normal temperature of e.g. 20°C, amount to 10% but may result in e.g. ± 37% in total on account of the temperature dependence of the coil resistance. Thus, e.g. given a nominal resistance of 178 Ω at 20°C, given a tolerance of ± 10%, the value may amount to 121 Ω at -40°C and 245 Ω at +85°C.

The use of a changeover switch in which, in the first switching position of the changeover switch, the control line of the current source is connected to a voltage potential which effects a current through the constant-current source and exciter coil which is greater than or equal to the required pull-in current of the exciter coil and in which, in the second switching position of the changeover switch, the control line of the current source is connected to a voltage potential which effects a current through the constant-current source and exciter coil which is greater than or equal to the required holding current of the exciter coil results in a further simplified construction which enables loads that are to be switched to be supplied with energy if the changeover switch is in the first switching position.

The use of a second changeover switch which can be changed over from the first into the second switching position at the same time as the first changeover switch results in a construction in which the load to be switched can be switched as desired.

A further component reduction is achieved by embodying

the second changeover switch as second changeover switch of the first relay which is changed over at the same time as the first changeover switch, e.g. by mechanical coupling. Furthermore, this ensures in a simple manner that the current through the constant-current source is reduced only when the relay has already pulled-in and only the reduced holding current is required.

By using an additional relay with the second changeover switch, it is also possible to use relays with only one changeover switch in order to be able to switch the load as desired. A voltage-controlled current source of simple construction is achieved by virtue of the fact that a voltage divider can be connected up to the second changeover switch.

A construction with minimal outlay on components can be realized if the current source is embodied as a bipolar transistor circuit in which the emitter of the transistor is connected to the first pole of the supply voltage via a resistor, in which the collector of the transistor is connected to the second pole of the supply voltage via the exciter coil of the relay, in which the base of the transistor is connected to the control voltage via a resistor, and in which, in the second switch position of the changeover switch, a resistor or a reverse-biased zener diode is connected in between the base of the transistor and the first pole of the supply voltage and, consequently, a voltage divider is realized which reduces the voltage present at the base of the transistor.

A similar construction can be realized using a field-effect transistor, which differs from the above-described bipolar transistor circuit in that the base terminal is replaced by the gate terminal, the collector terminal is replaced by the drain terminal

and the emitter terminal is replaced by the source and substrate terminal.

Voltage spikes which can arise as a result of switching operations in the exciter coil are effectively short-circuited by a capacitor or a zener diode which connects the collector terminal of the transistor or drain terminal of the field-effect transistor to the first pole of the supply voltage. The transistor or field-effect transistor is thus advantageously protected against possible damage.

The electromagnetic compatibility of the drive circuit according to the invention is advantageously improved by a capacitor between the base terminal of the transistor or the gate terminal of the field-effect transistor and the first pole of the supply voltage.

By increasing the capacitance of the above-described capacitor, the drive circuit can be made even more reliable if an additional resistor is connected between said capacitor and the base or the gate. As a result, the changeover from the pull-in current to the lower holding current is carried out according to the form of an exponential curve.

The invention is described in more detail below with reference to the figures for two particularly preferred configurations of the drive circuit according to the invention. In the figures:

Figure 1 shows the circuit diagram with a bipolar transistor and two changeover switches,
Figure 2 shows the circuit diagram with a field-effect transistor and a changeover switch.

In **Figure 1**, a transistor T is connected, by its emitter, to the ground potential via a resistor R3 and,

by its collector, to the positive pole of the supply voltage UB via the exciter coil RS. The base of the transistors T is connected to the control voltage UE via a resistor R1. The control voltage UE is thus present almost in its entirety at the base of the transistor T, since the voltage drop across the resistor R1 is small on account of the low base-emitter current. A resistor R2 is connected to the changeover switch S1 in such a way that it connects the base of the transistor T to the ground potential in the pulled-in state of the relay armature. A capacitor C1 connects the collector of the transistor T to the ground potential, and the capacitor C2 connects the base of the transistor T to the ground potential. The control voltage UE corresponds to the ground potential if the changeover switches S1, S2 are intended to be in their first switching position, and is increased to a specific value (e.g. 5V when UB = 12 V) if the changeover switches S1, S2 are intended to move into the second switching position and remain there for as long as the specific value of the control voltage UB persists. If an input voltage UE having a specific value is applied, the transistor T turns on and a current which is greater than or equal to the required pull-in current flows through the exciter coil RS. The relay armature pulls-in and switches the changeover switches S1 and S2 from the first position (illustrated in **Figure 1**) into the second switching position. As a result, the resistor R2 connects the base of the transistor T to the ground potential via the switch S1. The voltage divider thus formed by the resistors R1 and R2 reduces the voltage at the base of the transistor T relative to the ground potential, so that the current through the collector of the transistor T and thus the exciter coil RS is reduced. The resistors R1, R2, R3 are to be dimensioned such that, in the range of permissible tolerances of the supply voltage UB, the exciter coil RS reliably changes over the changeover

switches S1 and S2 into the second switching position by means of the relay armature and holds them in said second switching position as long as the control voltage UE is at its nominal value, without exceeding the permissible holding current. The terminals A1, A2 and A3 of the changeover switch S2 can be connected up in accordance with the desired circuit purpose.

In **Figure 2** the field-effect transistor FET is connected by its source terminal and its substrate terminal, to the ground potential via the resistor R6 and, by its drain terminal, to the positive pole UB of the supply voltage via the exciter coil RS of the relay. The gate terminal of the field-effect transistor FET is connected to the control voltage UE via the resistor R4. A resistor R5 is connected to the changeover switch S1 in such a way that it connects the gate terminal of the field-effect transistor FET to the ground potential in the pulled-in state of the relay armature, i.e. if the changeover switch S1 is in its second switching position.

The load L to be switched is continuously connected to the second pole UB of the supply voltage. In the first switching position (illustrated in **Figure 2**), the switch S1 connects the load L to be switched to the first pole (ground potential) of the supply voltage. Consequently, with only one changeover switch S, as a result of the pull-in of the relay armature, the voltage divider can be connected up and the load to be switched can be disconnected. The resistor RX effects a gradual changeover from the pull-in current to the holding current since the capacitor C2 can only discharge slowly to the reduced control voltage. The zener diode Z protects the field-effect transistor FET from voltage spikes.

The capacitors C1, C2 correspond to the identically

designated components in **Figure 1**. The method of operation corresponds to the circuit described for **Figure 1**.

The circuits described above represent solutions to the object set which are of particularly simple construction and inexpensive yet reliable. Other configurations of the invention are also possible, such as e.g. with current sources realized with the aid of operational amplifiers.

Patent Claims

1. A drive circuit for a relay which has at least one exciter coil (RS) with relay armature and a changeover switch (S1), in which case, in the event of a specific minimum current through the exciter coil (RS), the changeover switch (S1) can be changed over from a first switching position into a second switching position by the relay armature, and in the case of which the current through the exciter coil can be reduced, after the changeover of the changeover switch (S1), to a value which is greater than or equal to the required holding current, characterized
in that the exciter coil is connected in series with a constant-current source between the poles of the supply voltage,
in that the constant-current source can be set to different current values.

2. The drive circuit as claimed in claim 1, characterized
in that the constant-current source has a control line,
in that, in the first switching position of the changeover switch (S1), the control line is connected to a voltage potential which effects a current through the constant-current source and exciter coil which is greater than or equal to the required pull-in current of the exciter coil, and
in that, in the second switching position of the changeover switch (S1), the control line is connected to a voltage potential which effects a current through the constant-current source and exciter coil which is greater than or equal to the required holding current of the exciter coil.

3. The drive circuit as claimed in claim 1 or 2, characterized in that a second changeover switch (S2) is present, which can be changed over from a first into

a second switching position at the same time as the first changeover switch (S1).

4. The drive circuit as claimed in claim 3, characterized in that the first relay has the second changeover switch (S2).

5. The drive circuit as claimed in claim 3, characterized in that the second changeover switch (S2) is present in a second relay whose exciter coil is connected in series or in parallel with the exciter coil (RS) of the first relay.

6. The drive circuit as claimed in one of the preceding claims 2-5, characterized in that a voltage divider can be connected up to the first changeover switch (S1).

7. The drive circuit as claimed in claim 6, characterized
in that the current source is formed by a bipolar transistor (T), the emitter of the bipolar transistor (T) being connected to a first pole of the supply voltage via a resistor (R3), and the collector of the bipolar transistor (T) being connected to the second pole of the supply voltage via the exciter coil (RS) of the relay or the exciter coils of the relay, and the base of the bipolar transistor (T) being connected to a control voltage (UE) via a resistor (R1),
in that a resistor (R2) or a reverse-biased zener diode is connected between the base of the transistor (T) and the first pole of the supply voltage if the changeover switch (S1) is in the second switching position.

8. The drive circuit as claimed in claim 6, characterized
in that the current source is formed by a field-effect transistor (FET), the source terminal of the field-

effect transistor (FET) being connected to a first pole of the supply voltage via a resistor R6, the drain terminal and the substrate terminal of the field-effect transistor (FET) being connected to the second pole of the supply voltage via the exciter coil (RS) of the relay or the exciter coils of the relay, the gate of the field-effect transistor (FET) being connected to the control voltage (UE) via a resistor (R4),
in that a resistor (R5) or a reverse-biased zener diode is connected between the gate terminal of the field-effect transistor (FET) and the first pole of the supply voltage if the changeover switch (S1) is in the second switching position.

9. The drive circuit as claimed in claim 7 or 8, characterized in that a load (L) to be switched is connected to the first pole of the supply voltage via the first changeover switch (S1) in the first switching position.

10. The drive circuit as claimed in claim 7 or 8, characterized in that the load to be switched is switched via the second changeover switch (S2).

11. The drive circuit as claimed in claim 7, 8 or 10, characterized in that a capacitor C1 and/or a reverse-biased zener diode (Z) is connected between the first pole of the supply voltage and the collector terminal of the transistor (T) or the drain terminal of the field-effect transistor (FET).

12. The drive circuit as claimed in one of claims 7 to 11, characterized in that a capacitor (C2) is connected between the first pole and the supply voltage and the base terminal of the transistor (T) or the gate terminal of the field-effect transistor (FET).

13. The drive circuit as claimed in one of claims 7 to 12, characterized in that a resistor (R_X) is connected between the second capacitor (C2) and the base of the transistor (T) or the gate of the field-effect transistor (FET).

Accompanied by one page of drawings

Relay holding circuit

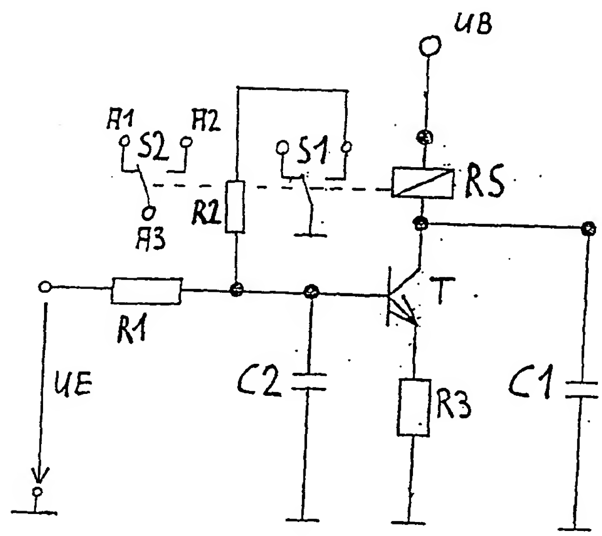
UB
A1
S2
A2
S1
RS
R2
A3
T
R1
UE
C2
R3
C1

Fig. 1

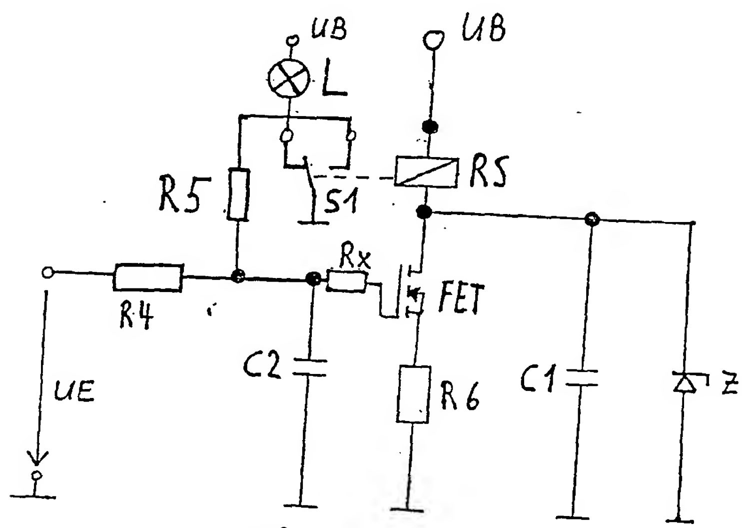
UB
L
UB
RS
R5
S1
Rx
FET
R4
C2
UE
R6
C1
Z

Fig. 2